DEHYDRATION OF FRUITS AND VEGETABLES

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Just as the Civil War stimulated the canning industry in the United States, the Boer War and World War I stimulated the dehydration industry. To conserve cargo space and transportation facilities, large quantities of foods were dehydrated during both World Wars and shipped to the Allied armies in Europe.

Apples have been dehydrated (or "evaporated") in America for at least a hundred years, and the dehydration of prunes in the Pacific Northwest is an old and important industry. On the other hand, dehydration of vegetables has from its very beginning been primarily a War measure.

Dehydration of Fruits:

Until quite recently, Asia Minor, Greece, Spain, and other Mediterranean areas produced most of the World's supply of sun-dried fruits. At the present time, about one-half of the World's production of dried fruit comes from the United States. The 1950 dried fruit output in the United States amounted to about 374 thousand short tons, which is 135 thousand tons less than in 1949. California is now the most important producer of raisins, dried peaches, prunes, and apricots.

Until about 1920, most dried fruit produced in California was dried in the sun. Heavy financial losses due to early rains ultimately induced large-scale construction of tunnel dehydrators, the use of which not only gave insurance against losses from rain damage, but resulted in an improvement of the product by elimination of field contamination and insect infestation. At present, over 80 percent of the prune crop is dehydrated, but apricots,

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Until quite recently, Asia Minor, Greece, Spain, and other Mediterranean areas produced half of the world's supply of sun-dried fruits. At the present time, about one-half of the world's production of dried fruits comes from the United States. The 1951 dried fruit output in the United States amounted to about 396 thousand short tons, which is 219 thousand tons less than in 1946. California is now the most important producer of raisins, dried peaches, prunes, and apricots.

Until about 1920, most dried fruit produced in California was dried in the sun. Heavy financial losses due to early rains at harvest induced large-scale construction of tunnel dehydrators, the use of which not only gave insurance against losses from rain damage, but resulted in an improvement of the product by elimination of field contamination and insect infestation. At present, over 90 percent of the prune crop is dehydrated, but apricots,

pears, peaches, and nectarines are still, for the most part, dried in the sun. Apples are commonly dried in kiln driers, but dehydrators are coming more into use.

Practically all the research accomplished in the United States on the drying and dehydration of such fruits as prunes, peaches, raisins, and apricots has been conducted by workers at the University of California and the University of Oregon.

The work of the Bureau of Agricultural and Industrial Chemistry on fruit dehydration has been confined chiefly to the development of commercially feasible processes for the manufacture of prune and fig powders, and the dehydration of orange juice. Fig powders have been prepared from commercially dried figs by tunnel, vacuum and drum drying procedures. It has been found that the minimum amount of heat damage was incurred in vacuum drying, but that drum drying and tunnel drying procedures resulted in satisfactory products. The latter powders possessed a characteristic fig flavor and in addition a slightly caramelized flavor which was considered pleasing. It is believed that both prune and fig powders may have a place in certain baked goods and breakfast cereals.

Apple nuggets have found wide use in the Military and during World War II large amounts were used in the Army. The product is prepared by coarsely grinding dried apples and then drying in vacuo to less than 1 percent moisture content.

At the present time, the Bureau of Agricultural and Industrial Chemistry is starting researches on the dehydration of blueberries, cherries, and cranberries. Although dehydrated cranberries may be found on the American market, there is a possibility of improving the product.

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Researches have been undertaken in the preparation of dehydrated orange juice. During World War II, dehydrated orange juice was produced

commercially in Florida, but technical difficulties in production and short shelf life of the product caused subsequent abandonment of the project. Both dried orange and lemon juices are found on the American market, but they contain corn sirup solids as a spreader, and the product contains only from about 18 to 25 percent citrus solids. The work of the Bureau of Agricultural and Industrial Chemistry has been along the line of dehydration with minimum use of spreaders, and the addition of antioxidants to increase the storage life of the product. A stable dehydrated orange juice would be of interest to the Military.

The California Fruit Growers Exchange has recently announced the preparation of a dehydrated orangeade. This product is prepared by buffering orange juice with sodium carbonate and calcium carbonate, concentrating in vacuo to 80-85° Brix and then adding calcium carbonate and sucrose. The pasty mass thus obtained is spread in shallow pans and vacuum dried at 50° C. and about 20 mm. pressure to 0.5 percent moisture.

Dehydration of Vegetables:

In 1950, production of dehydrated vegetables amounted to about 30 thousand short tons, 20 thousand of which consisted of potato products.

An improvement in preserving the quality of dehydrated carrots has been achieved by starch coating the carrots prior to dehydration. Starch coating of dehydrated carrots is now applied commercially in the United States. In 1946, Tomkins, Mapson, and Wager, working in England, published their results on the value of starch coating carrots for dehydration and, in 1948, received a British patent on the process.

Non-enzymatic browning of dehydrated vegetables during storage has always been a problem to the industry. Although this problem has received wide attention in recent years, there have been no objective methods for measuring the degree of browning. The Bureau has presented methods for

measuring the degree of non-enzymatic browning in dehydrated white potatoes, carrots, cabbage, sweet potatoes, and onions.

Considerable research is being conducted on dehydrated potatoes which can be quickly reconstituted to give a mashed potato. Many patents, both British and American, have been issued for the preparation of potato granules and the key to successful production seems to lie in rupturing as few of the starch cells and cellulose structure as possible. Of the many processes proposed for making granular potatoes, practically all are based on the assumption that there is a critical moisture content at which it is necessary to granulate the cooked tubers in order to keep cell rupture to a minimum. This moisture content is attained either by adding back a portion of material already dried or by freezing the cooked tubers, thawing and then centrifuging or pressing. Other possibilities are being considered.

The proper methods of sulfiting potatoes prior to dehydration are being investigated. For instance, potatoes may be sulfited by combustion gas during direct fired drying, by sprays of a sulfite salt or by SO_2 gas, the purpose of the sulfite, of course, being to retard browning during storage. In this connection, it has been found that browning is quite slow for sulfited samples in the first part of the storage period, while substantial amounts of sulfite remain. This period of slow initial browning can be greatly prolonged by low moisture and by combination of sulfite, and low moisture dehydrated potatoes can be held for long periods of time with little, if any, detectable change.

Unfortunately, some people are more sensitive to sulfite flavor than are others, and experiments are under way to determine at what level these sensitive people can definitely recognize sulfite in reconstituted dehydrated potatoes as well as other dehydrated vegetables containing sulfite.

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Potato flour, cooked and uncooked, is produced in the United States chiefly for export to France, Germany, and other European countries. It has

been found that steam tube rotary driers can be used to produce potato flour. To prevent the material from sticking to the drier, moisture content of the ground potato is reduced to about 43 percent by continuously recirculating a sufficient quantity of the dried product and thoroughly mixing it with the moist material.

Although demand for potato flour is not great in the United States, addition of the flour to bread, crackers, and other baked goods gives added "bloom" or color to the crust and interior of the baked goods and they maintain their freshness longer. Doughs containing potato flour have a greater water absorption capacity than doughs containing only wheat flour.

Basic studies are being conducted on the rate of heat damage of potatoes at various temperatures and moisture levels encountered during dehydration. Tentative results indicate that somewhat less heat damage occurs in two-stage tunnels than in single-stage tunnels under comparable conditions, but further investigation will be necessary to test this indication. Reference should be made here also of the fundamental work on dehydrated vegetables and fruit being conducted at the Low Temperature Research Station, Cambridge, England; the Institute of Food Technology at Munich, Germany, and that at the Government Chemical Laboratory, Cape Town, South Africa. Undoubtedly, those countries behind the Iron Curtain are concerned with dehydration, but, so far as known, there is nothing available after Spiridonov's book on "Concentrated Foods," published in 1942.

Experience gained during World War II has shown that dehydrated sweet potatoes of initially acceptable quality can be produced on a commercial scale if raw material of sound quality is used. Although information is available regarding the processing conditions which have been used, there is need for more complete data on the effect of degree of blanch and drying conditions on

For compressed dehydrated foods to be successful they must:

1. Be palatable when reconstituted;
2. Have high nutritive value;
3. Have a pleasing appearance;
4. Be easy to prepare;
5. Maintain desirable properties for a considerable length of time when stored in available facilities;
6. Be available in units adapted to the needs of the consumer;
7. Be reasonable in cost.

Further research is necessary on such problems as improved presses, optimum moisture content for compressing the different commodities, most favorable packaging materials, storage life of compressed products, change in composition of the stored product, relation of handling to shattering of the compressed product and necessary further dehydration of the compressed product.

Dehydrofreezing:

This technique was first reported by Howard and Campbel of the Bureau of Agricultural and Industrial Chemistry in 1946. The process consists of moderate dehydration (removal of from half to two-thirds of the water) followed by freezing storage. This results in savings of weight, space, packaging materials, and refrigeration load. The method has been applied on a pilot plant scale to peas, apples, peaches, apricots, and prunes. The results have been quite encouraging and not only has interest been expressed in the product by the Navy, but, in the case of dehydrofrozen fruits, pie bakers have been particularly impressed. However, further studies are necessary, for example, on the optimum percent of moisture to be removed from different products, extent of heat damage during dehydration, and storage life of the product. Further research is also necessary on equipment design because it is important that dehydration be uniform. For example, each piece of the product leaving the dehydrator should be as nearly at the same moisture content as every other piece.

Dehydrocanning:

This implies the partial removal of water by dehydration followed by subsequent packing into cans and heat processing. The method is still in the experimental stage and at the present time the process is being applied to whole fruits or fruits in piece form as well as on liquid-form fruit products. Considerable more research is necessary to test the efficiency of heat processing of the canned product and this will involve use of inoculated packs. It will also be necessary to carry out comprehensive storage studies on the various dehydrocanned fruits. Such studies will be designed to evaluate the effect of various factors on keeping quality; for example, moisture content of the partially dried products, type of tin container, amount of oxygen after closure and storage temperature.

Engineering Aspects:

It is desirable to have more quantitative data relative to drying rates and browning rates. Like all chemical reactions, browning is accelerated by raising the temperature of the material. Browning will occur even at room temperature, but at 150° F. an amount of browning will occur in a few hours which would require months or, perhaps, years at 70° F. Thus, what we try to do in dehydration is make the rate of drying win a race with the rate of browning. Raising the temperature accelerates both, but browning more than drying. Once we have more quantitative data about these drying and browning rates, we believe that it will be possible to design a dehydrator rationally (or specify operating conditions for an existing dehydrator) so as to give the maximum output of product at an acceptably low level of browning. From results already obtained, it would seem that the two-stage tunnel will give higher capacity (at equal product quality) than the single stage counterflow tunnel. But the two-stage tunnel will do this only at the expenditure of

higher capital cost or operating cost, or both (per pound of product). We do not know at present at what point best balance will be had. Further attention should be given bin-finishing. It would be possible to increase the capacity of dehydrators greatly if they could discharge product at, say, 12-15 percent moisture content. Theory and practice of bin-finishing are, however, only beginning to be understood. Research on bin-finishing is one of the Bureau of Agricultural and Industrial Chemistry's important current dehydration projects.

Concentrated Fruit Juices:

Commercial packs of concentrated fruit juices are increasing in the United States. This is particularly true of citrus concentrates. During the 1949-50 season, for instance, the total pack of frozen citrus concentrates in the United States amounted to 28,104,796 gallons and during the 1950-51 season in Florida alone somewhat over 31 million gallons of frozen citrus concentrates were packed. Besides frozen citrus concentrates, there is also what is termed in the trade as "hot pack" concentrate which is not frozen but which must be kept under cool storage. Pack of this type of citrus concentrates amounts to about 5.5 million gallons per year.

Perhaps the most urgent research problem is concerned with the gelation of such concentrates. This is probably due to the demethylation of the pectin in the juice by pectic enzymes which are not inactivated at processing temperatures. The problem of gelation is a very important one from the standpoint of consumer acceptance and several independent laboratories are investigating the mechanism of the reaction and means of overcoming this phenomena.

Considerable research has been undertaken in the preparation of apple concentrate. Early in the history of frozen apple concentrate, it was believed that this could be prepared in the same manner as frozen citrus concentrates; however, it was soon learned that this method is not effective and that a more

satisfactory technique consists of concentrating the juice at temperatures somewhat higher than used for citrus concentrates, trapping the natural apple flavors, then adding this flavor back to the concentrated juice and then freezing the product. In the case of apple concentrate that is not to be frozen, concentration is carried to a higher Brix and the recovered flavors added to the concentrate.

Excellent engineering progress has been made in designing equipment for the recovery of natural fruit flavors. At the present time in the United States, natural apple and grape flavors are produced commercially. No satisfactory evaporative method has as yet been devised to recover flavor from citrus juices. Research is under way in recovery of natural flavors from strawberries, raspberries, Boysenberries, peaches, and apricots. Newly devised chromatographic methods of analyses have greatly aided in determining the chemical composition of many of these natural flavors.

The process of preparing frozen citrus concentrates involves the adding back of fresh juice which replaces at least, in part, the volatile flavoring constituents lost during concentration. Thus the juice is concentrated to about 58° Brix and fresh juice added until the concentrate is about 42 or 43° Brix. It is expensive to concentrate to 58° Brix and researches are under way to evaluate the possibility of trapping the natural flavors and adding them back to the juice so that concentration would only have to be carried to 42 or 43° Brix. There are some indications that the characteristic flavor of orange, for instance, comes mainly from the essential oil in the peel and encouraging results have been obtained by adding peel oil. However, it has been found that not all peel oils are satisfactory and it is not known as yet what constitutes a satisfactory peel oil for this purpose.

In the case of concentrated fruit juices, such as apple, grape, and citrus, that are not frozen, it is generally necessary to store these at temperatures around 40° F. to prolong storage life. Grape and apple concentrates can be kept at room temperature for a reasonable period of time, but citrus concentrates quickly darken in color and evolve carbon dioxide, resulting in swells. Research workers are, therefore, concerned in evolving some method by means of which such fruit concentrates can be stored at room temperatures.

In summary, it may be said that dehydration of fruits and vegetables are becoming of increasing interest both from the Military point of view, and their potential value in times of emergency feeding. Further researches are needed to improve the storage life of the products, improve existing products and the development of new products. Studies are particularly needed in the engineering field regarding improvement in design of dehydrators for greater efficiency, and in the design and use of bin-finishing.

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